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ABSTRACT

Optimum time for efforts to attract minority students to a science career is when the students are enrolled in grade school and junior high school rather than at undergraduate and graduate levels, where many present programs are aimed. Student population is at its maximum in grade school, and successful efforts will reduce the amount of remedial work needed later. Attitudes which should be instilled during grade school in minority students, specifically Chicanos and Native Americans, include a feeling that science and mathematics are fun and that science is relevant to the child's culture, and a feeling of identification with men and women who are scientists and of self-worth and confidence in dealing with scientific and math concepts. These goals may be accomplished through "magic shows" using several standard demonstrations, i.e., chemical snake and the iodine clock reaction, to give minority grade school children a feeling that science is fun, teach them fundamentals, and present role models; culturally oriented classroom materials which show the interaction of science and native cultures; and computer programming as a learning strategy to teach problem solving. Minority scientists should be developing curricular materials along these lines and pressing for funding to work in these areas. (RS)

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MAGIC, MYTH AND MINORITY SCIENTISTS

Presented to a meeting of the
Society for the Advancement of Chicanos and Native Americans in Science
SACNAS
Boulder, Colorado
February 26, 1978

by
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The Bakke case is just one manifestation of a growing backlash claiming "reverse discrimination" which will further weaken what has never been a real commitment of affirmative action in this country. One approach which may be less successful to attack on these grounds is that of the development of a large enough pool of minority applicants so that a "color blind" competition produces an equitable result. This after all is the ultimate goal towards which affirmative action is supposed to work. The original conception was that affirmative action programs would function until they were no longer necessary and then fade away. Compensatory programs may continue to be funded for a while but they cannot be the long term solution. We need to radically increase the number of Chicanos and Native Americans who choose scientific careers. At the same time we must attempt to make the best use of our limited resources to make maximum impact.

Many of our programs designed to encourage scientists are aimed at the late teens and early twenties. The Minority Biomedical Program as well as the proposed Resource Centers are aimed at undergraduate and graduate students. The realities are, though, that because this is not the optimum time to influence career decisions, a great many potential candidates have dropped out by this time. The most effective time for our intervention should be at the time when the target population is the largest and when opening up the idea of science as a career option would be most beneficial for the child. This time is when the students are enrolled in grade school and Junior High School. If Chicanos and Native Americans can be convinced at this level that science and mathematics are both desirable and possible for them, then there is time in which to take the foundation courses and the prerequisistes needed

to perform successful college work without the need to remedy massive deficiencies. Learning efficiencies are at their peak in these ages; the results would be worth the investment of our time.

Obviously the lack of motivation of Chicanos and Native Americans toward studying science is not the sole or perhaps even the main problem. To claim this would be just another example of blaming the victim for the problem. The problems of poverty, inadequate schools and of poorly trained teachers remain. No one proposal is the universal panacea, but progress in these other areas would be easier if a group of motivated students were pushing the teachers and the school system.

All of us could draw up lists of attitudes that should be instilled in our kids while they are in grade school and of experiences designed to improve their self-confidence. Mine would include the following: 1) A feeling that science and mathematics are fun things to do, 2) a feeling of identification with men and women who are scientists or who do science, 3) a feeling that science is relevant to the child's culture, and 4) a feeling of self-worth and confidence in dealing with these concepts. In this article, I would like to discuss the use of "magic shows", of culturally oriented class room materials, and of computer programming concepts as approaches to accomplishing these goals.

Chemistry and physics magic shows for grade school children

My own inclination toward science was not developed at home. My father was a poet, an occupation not guided by the scientific method. Yet, I was influenced early by the high-school chemistry teacher, who used to come to my 4th and 5th grade classes to give us small demonstrations of basic principles such as density, solubility and the

properties of materials. His demonstrations were always a lot of fun and influenced several of us to choose science as a career.

Years later, when I was Chairman of the Chemistry Department at St. Mary's University in San Antonio, we tried a variation of this idea which proved quite successful. Several members of the Chemistry Club put together a "magic show" using several standard demonstrations such as the "chemical snake", the iodine clock reaction and the use of indicators to change the colors of solutions with different pH's. Several grade school classes were invited to our campus, shown aroung the building and then given the magic show. The reception was quite enthusiastic and lively question-and-answer sessions developed, during which explanations of some of the tricks were used to explain some fundamental concepts to the children. An unexpected bonus was the enthusiasm which this generated in my students, who worked very hard at improving their own knowledge of the chemical basis of the tricks. We also noticed a generally improved attitude toward their studies.

If properly presented, chemistry and physics "magic shows" could give minority grade school children a feeling that science is fun, could teach them some fundamentals, and could present role models at the same time. Maximum benefits could be obtained in geographic areas with a high percentage of Chicano and/or Native American enrollment in the schools, and where there is an university with a significant number of minority students.

The presentations should be done predominantly by the corresponding minority students for a variety of reasons. They can serve as role models for the children and show that people like themselves are college students and deal with science. Also, we found at St. Mary's young

college students communicated better with the children than some of us older people. Further, this approach maximizes our resources. We all know the multiple demands that are placed on the few of us who are in academia: using college students as demonstrators makes it possible for one faculty member to train and counsel a group of students who can then go out and cover many more audiences than he or she could do alone.

A secondary benefit would be the effect on the college students themselves. We found in our project that the students also developed a more positive attitude toward science. Having them search the literature for possible demonstrations and for the corresponding explanations gives them a useful skill which they can use in research later.[1] More important, the praise and admiration of the children for whom they perform helps them to develop confidence and a positive self-image. A program which the YMCA-YWCA at the University of Texas ran in the early 1960's is a good example. Chicano Junior High School students were used as after-school tutors in a grade school with a high percentage of minority enrollment. As expected, they communicated well with the smaller children and the children's work improved. Unexpectedly, we found that the confidence which the tutors had gained also resulted in improvements in their own school work. Thus, in choosing demonstrators for these magic shows, it is probably desirable to involve students with different skill levels, so that they can benefit also. Work-study students who are not science majors could be used as well as science majors and students involved in the MBS and other special projects.

Culturally-oriented classroom materials

The lack of role models for Chicanos and Native Americans is not just due to a scarcity of scientists from these groups, but is also due a

presumption on the part of the schools that our cultures are either anti-scientific or at best a-scientific. There is a common belief that the western cultural heritage is particularly propitious to scientific development.[2] Lynn White traces this to early medieval times when the discovery of the moldboard plow changes man's relation to the soil -- from a part of nature to an exploiter of nature.[3] If this is true, where does it leave all New World cultures which never used a plow because they lacked animals to pull them? Another factor identified by White is that, "...Christianity especially in its western form is the most anthropocentric religion the world has seen ... it established a dualism of man and nature but also insisted that it is God's will that man exploit nature for his proper end. ... By destroying pagan animism, Christianity made it possible to exploit nature in a mood of indifference to the feelings of natural objects ...."[4]

Most of the material available on the development of science reflects this ethnocentric orientation. The scientific contributions of China, India and Islam are usually minimized and the traditional native cultures are usually depicted as permeated with superstition and magic, and thus not oriented towards science. This explanation can be used to attribute the small number of minority scientists to a deficiency in their cultural background and to exculpate the larger society. Octavio Romano has shown that past research in the social sciences was not value-free and that stereotypes about Mexicans have become social science gospel and contributed to the distortion of Mexican-American history. This same ethnocentricity has resulted in attribution of "scientific" aspects of Mexican folk medicine such as the "hot-cold" concept to a European contribution. On the other hand, superstitious aspects such as the

existence of witches are usually attributed to the Indians. I've tried to show, that at the time of the conquest, the exact opposite could have been equally plausible.[6]

This entire area of the scientific validity of the beliefs of native peoples and their supposed non-rational emotive thinking processes needs to be examined carefully. We need to put together curricular materials that show the connection between our cultures and science. We need to publicize examples of scientific knowledge in these cultures to show students that this type of activity is not alien to their background. We should not be trapped by excessively restrictive definitions of what constitutes science. As a minimal definition, Malinowski uses the following, "... a body of rules and conceptions, based on experience and derived from it by logical inference, embodied in material achievements and in a fixed form of tradition and carried on by some sort of social organization..."? He finds that many principles of native knowledge are scientific even when additional requirements such as, "... the rules of science must be laid down explicitly, open to control by experiment and critique by reason. They nust not only be rules of practical behavior, but theoretical laws of knowledge..." are imposed.[7]

I have found in my research that the Aztecs were accurate observers of the physiological effects of plants and could obtain the effects required by their etiological beliefs.[8] An investigation of other folk-medicinal systems using the same methodology would probably yield similar results. Recent studies concerning ethnobotany have shown that people who live close to nature have an extremely detailed and accurate knowledge of animals and plants, recognizing several hundred different species.[9] The interesting fact is that it took a long time for botanists

to take the native cultures seriously enough to conduct valid investigations. Although some work is now being done on Native American taxonomies, much more still needs to be done. An easy bridge to biological studies could be achieved by using the plant and animal names of a particular tribe, or those of Aztec origin in the case of Chicanos, as a starting point.

Native astronomy is another area in which there is a resurgence of research and the discovery of unsuspected sophistication.[10] This area or research could also be used to link a child's culture to scientific disciplines.

Native cultures have much to contribute to science, particularly in the area of ecology. It is becoming increasingly clear that there needs to be more interaction between ethics and values on the one hand, and science and technology on the other. The current debates concerning the possible uses of recombinant DNA research or the possible utilization of breeder reactors are cases in point. Our ecological crisis and the destructive effects of our technology on natural systems is becoming increasingly obvious. We will need to reconcile our needs for progress and production with the need to work along with nature, rather than trying to subjugate it as we have attempted to do in the past. Native Americans have always had an ecologic ethic in which humans strive to achieve a harmonious relation with nature. There are some clear statements of this ecological view, but much of it is encapsulated as myths, and the poetry, art and drama derived from them. Burch states that, "... Myths are collective representations which tell us about the kind of people we wish to be and why we should be that kind of people ... Myths then are the grammar and rhetoric of the social order. They not only regularize the flow of information but also convey feeling ... Myths are significant

metaphorical clues as to the value perceptions of a society and particularly its attitude towards nature. ..."[11]

We need to put together a set of readings in this area which could be used to motivate students to seriously consider biology and ecology as careers. These readings should include some of the direct statements of the Indian view of nature (some of the speeches of Chief Seattle for example[12]), myths, and their interpretations, together with the conclusions reached by modern ecological research which are congruent with these traditional values. There is a great need for people who are well trained in the sciences, but who also have an ingrained sense of reverence for nature. This is no longer a primitive whim, but eminently scientific wisdom. We must maintain diversity of species to maximize ecological stability, must make recycling a major societal goal, and shift to soft technologies. All of these goals have been embodied in various forms in native value systems. Curricular materials dealing with this aspect of the interaction of science and native culture could also be strong motivating forces to choosing scientific careers.

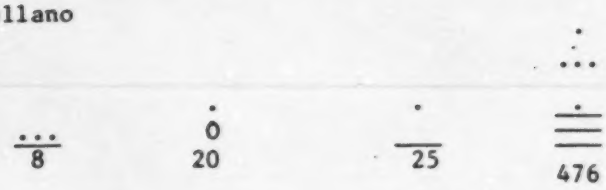
Maya arithmetic

Maya mathematics is another tool that can be used to point out that scientific discovery is relevant to Chicano culture. The concept of zero and place value notation are of crucial importance in the development of mathematics. They were not discovered by the great Greek mathematicians and were not known in Europe until the 12th century. They were transmitted to Europe by the Arabs who had acquired this knowledge from the Hindus. It is believed that the Hindu discovered the concepts around 500 B.C.[13] The place of Islam in stimulating science in Europe is often underrated.

It not only transmitted Hindu mathematics and the Greek wisdom lost in Europe during the Dark Ages, but also propagated an attitude of using knowledge to acquire power over nature.[14]

Only one other culture independently discovered these important concepts, the Maya. Their discovery may have antedated that of the Hindu. The complex Maya calendar, which required both of these concepts, was certainly known by 36 B.C. Thus, these mathematical concepts must have been developed many years before that in order to be used in the development of the calendar itself.[15] Other important Mayan discoveries are: 1) a measurement of the length of the year that is more accurate than our own Gregorian calendar, 2) the determination of the complex cycle of Venus with an accuracy of 0.08 day in 481 years, and 3) the construction of tables to predict when solar eclipses might be visible. All of these preceded their discovery in Europe.[16] Children should be made aware of these facts and encouraged to think of mathematics as pertinent to and a proud accomplishment of their culture.

George I. Sanchez, at the University of Texas, was a pioneer in this effort. His book, Arithmetic in Maya[17] was an attempt to make these methematical concepts accessible to children. He told me some time ago that he could teach Mayan calculations to school children in two or three sessions. The Maya system has three symbols: zero; — five; • one. It is vigesimal rather than a decimal system, and the different exponential levels are placed vertically rather than horizontally as in the Hindu-Arabic system. The progression is 1; 20; 400; 8000; 160,000; 3.2×10^6 etc. rather than 1; 10; 100; 1000. Examples of some numbers are: (using an open circle instead of a shell for ease of writing)

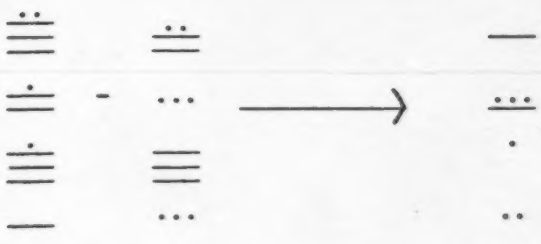


Addition involves only counting of symbols at the various levels, while subtraction requires cancelling of symbols. Some examples follow:

11 + 7

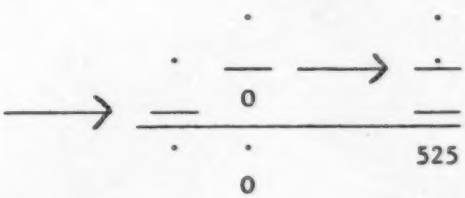
332 + 75

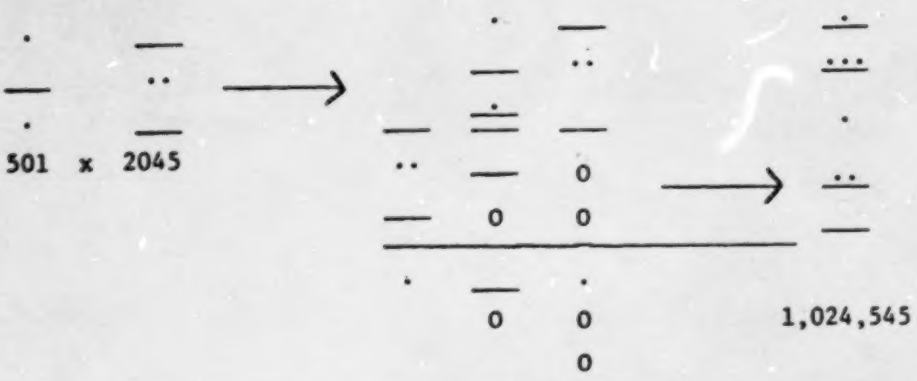
140,725-97,503

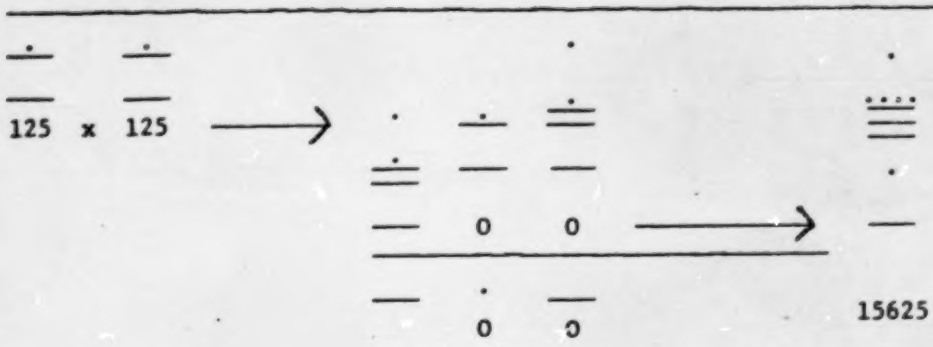


Multiplication consists of multiplying each character of the right hand number by each character of the left hand number retaining the proper levels. Examples:

21 x 25 →

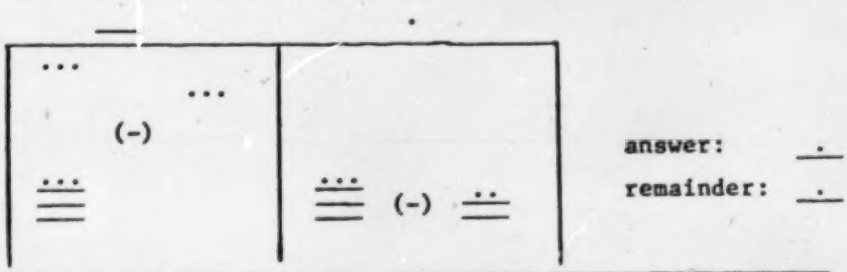




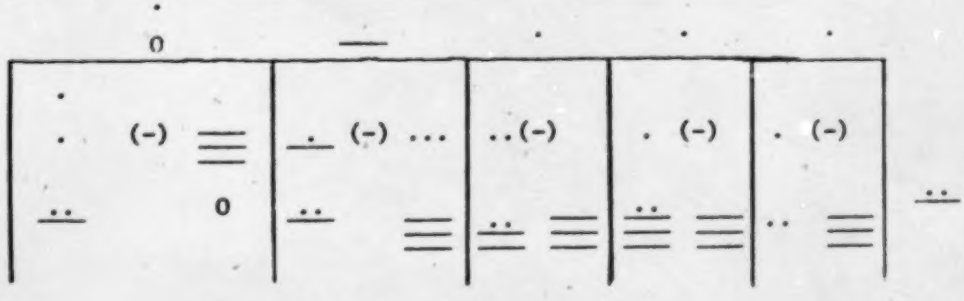


Division consists of succesive subtraction of multiplicands of the divisor. It has one advantage over our system: it does not matter which one is chosen first. For example:

78 ÷ 12



475 ÷ 15



answer:

remainder:

Anderson[17] gives a procedure for extracting square roots using Maya numerals; I'm sure that a variety of other mathematical procedures could be demonstrated. Sánchez points out that these calculations can be carried out much faster using counters like an abacus. Objects such as pennies, beans and pebbles could be used in classroom demonstrations.

Computer programming as a remedial strategy

The University Studies/Weekend College program at Wayne State University is a program whereby working adults can get a degree in General Studies in four years while working full-time. This is accomplished using a combination of daily television programs, a four hour weekly workshop and two intensive weekend sessions each quarter. All students are required to take 3 quarters of interdisciplinary science and technology courses centered on ecology, energy and the interaction between science, values and technology. We are thus faced with the necessity of trying to teach a meaningful amount of science at the liberal arts level to all students.

Our students are predominantly blue-collar members of the United Auto Workers. They are for the most part, married, in their 30's, veterans and have not been in school for a long time. There is a significant black minority, but very few Chicanos or Native Americans. Many of our students resemble minority students I've had before in that they have a very poor self-image of their capabilities in the classroom. Although many of them are quite bright, they were poor students in high school, or attended bad schools in ghetto areas. The long absence from academic pursuits tends to aggravate their self-doubt. In common with minority students, they are particularly apprehensive about mathematics, science and writing essays.

I've come up with a strategy that seems to work with our students in doing remedial work on problem-solving skills and should be applicable to minority students. One of our workshop courses is an introduction to computers: how they work, and both the good and bad impacts they may have on our society. As a part of the course we try to teach the rudiments of FORTRAN programming so that the students can get a better feel of the detail with which computer instructions need to be written.

I have found that this technique has a great potential for teaching problem-solving. It has several advantages in this respect. First - - it can be used to teach how to deal with word problems, which are more difficult than drills on arithmetical techniques. Second - - it removes the psychological stigma of "being dumb" from the student himself and transfers it to the computer. One of the basic problems that students encounter in solving problems is that they try to conceptualize the entire solution in one step rather than in small incremental steps. We have found that students who have trouble with mathematics don't begin by breaking problems down into small steps because they feel that if they have to resort to this strategy for problems such as calculating percentages or calculating simple interest they demonstrate their stupidity. They feel that since their more adept classmates can do these problems in one conceptual leap, inability to do so is an indication of failure. They fail to realize that one must break down problems before one is capable on one-step conceptualization, and that people who are adept at mathematics were able to get through that step at an early age. Programming a computer to solve a problem involves breaking down the problem into very small conceptual steps and thus forces the student

to analyze the problem in order to be able to do this. Since both the students who are adept at math and those who are not have to break down problems into small bits to be able to write a program, the onus is removed. The"dumb" thing is the computer and not the programmer. It is then possible to get students to drill in breaking down steps into small steps and eventually achieving some skills at dealing with word problems involving some arithmetical concepts.

The benefits can be realized even if the programs are never run on a computer. In our classes we use a telephone-coupled remote terminal to give our students at least one demonstration a quarter on how the computer handles their program. Another advantage of this approach is that it is inherently self-paced and it is still able to provide rewards for all the students in a class with a range of abilities.

The following is an example of the approach used:[18]

Step 1 IDENTIFY the information needed to solve the problem. This information is called the INPUT. Collect items, lists and tables of input as needed.

Step 2 IDENTIFY the information desired for the solution. This information is called the OUTPUT. Specify items, lists or tables of output as needed.

Step 3 SPECIFY how you would go about finding the desired output from the given input. Perform sample calculations and logical decisions which would find the output information if enough time and space were allowed.

Problems are performed by several iterations. The class first performs the above steps orally using their own words to describe the steps.

The role of the teacher is to coax them along and try to get them to develop alternate ways to solve the problem since the object is to encourage the idea that there may be several "correct" programming solutions. This again is a mechanism to encourage the student to have self-confidence and not to be cowed by someone else's solution.

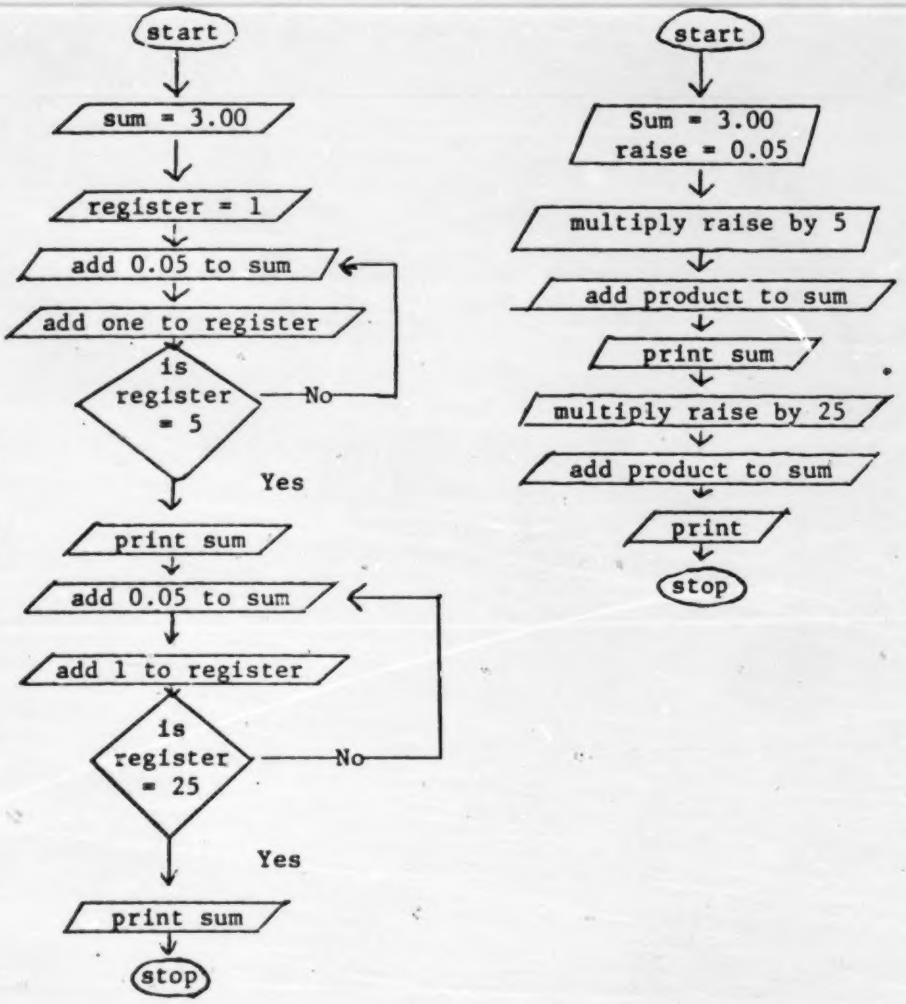
After doing a variety of problems this way, flowcharting elements are introduced and the solutions worked out orally are flowcharted. The third step is to give the students a short FORTRAN dictionary and get them to write the problem out in the language. Any language could have been used at this stage. We are experimenting with BASIC since this would allow us to use microcomputers in the classroom for more immediate reinforcement. The benefits in learning how to work out problems is realized in the first two stages. No attempt is made to teach the student how to program the computer to accept data or the output format since the effort would be too great compared to the knowledge gained.

One of the problems used is the following: Smith has a starting wage of $3.00 an hour with the promise of 5¢ an hour raise after each twelve month period. Find Smith's expected hourly wage after 5 years. 25 years. Two solutions proposed by students are shown below, in Figure 1.

One of the points that can be made in class discussion is that different readings by the students of the desired output will radically alter how a problem will have to be flowcharted and solved. This can be used to deal with the common problem that science students have with word problems, i.e., not reading the problems carefully and solving for

the wrong quantity or using the wrong input. Another point that can be made is that if we wanted to print out at yearly intervals, Program I is the one more easily altered to the new requirements. To demonstrate that a type II solution is not always available, the next problem reads as follows: Jones has a starting salary of $10,000 per year with

FIGURE I



I II

a promise of a yearly raise of 5% of the previous year's salary. Find Jones's salary and raise for each of the first five years. 25 years. Many kinds of problems can be adapted to this approach. The complexity depends on the ability of the class.

This article presents several suggestions to attempt to induce young minority students to consider science as a career. Other approaches can be devised. The important factor to remember is that the student population is at its maximum in grade school and that successful efforts at this level will reduce the amount of remedial work needed at a later date. We as minority scientists should be developing curricular materials along these lines and pressing for funding to work in this area. Work at this level can be accomplished for a lower cost than graduate training of scientists and may prove to be more beneficial in the long run.

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